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Influence of wind erosion on dry aggregate size distribution and nutrients in three steppe soils in northern China

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ABSTRACT

Wind erosion is a key process that causes soil degradation in the semiarid steppe regions of northern China. However, few studies have quantitatively measured the changes in dry aggregate distribution and nutrients in steppe soils under continuously varying wind erosion intensity. The objectives of this study were as follows: (1) to explore the different responses of three steppe soils to natural windblown treatments and (2) to quantify the changes in soil dry aggregate distribution, particle size distribution and soil nutrient contents under various wind erosion intensities for three steppe soils. We obtained samples of the following soils subjected to varying wind intensity via a natural windblown treatment: meadow steppe (MS), typical steppe (TS) and desert steppe (DS). Then, the physical and chemical properties of all soil samples were measured. The results showed that dry aggregate fractions < 0.2 mm were selectively depleted by wind erosion and exhibited an exponential decrease in the residual soils with increasing wind erosion intensity. The organic carbon (OC), total nitrogen and available nitrogen in the three soils and the total phosphorous and available potassium in the TS and DS soils showed exponential decreases with increasing wind erosion intensity. The higher amounts of OC and nutrients were associated with fine dry aggregates (< 0.2 mm), and fine dry aggregates were preferentially depleted by wind erosion, providing a mechanism for nutrient depletion caused by wind erosion. Finally, we established a comprehensive conceptual model of fine soil aggregate/particle depletion by wind erosion and subsequent nutrient depletion due to anthropogenic disturbances in temperate steppe areas.

1. Introduction

Wind erosion is a common phenomenon in many arid and semiarid areas around the world and can influence soil texture and associated soil nutrient balances (Gillette and Hanson, 1989; Lawrence and Neff, 2009; Okin et al., 2004; Poortinga et al., 2011; Prospero et al., 2012; Shinoda et al., 2011; Yan et al., 2013, 2015). Several studies have revealed that wind erosion causes soil degradation by directly depleting fine particles and associated nutrients, especially in arid and semiarid areas (Li et al., 2007; Yan et al., 2013). Meadow steppe (MS), typical steppe (TS) and desert steppe (DS) are three types of grasslands distributed from east to west in Inner Mongolia based on the natural climate and vegetation conditions. In past decades, the degradation of the grassland area in Inner Mongolia has reached > 90% due to inappropriate overgrazing and cultivation (Yan et al., 2010). Moreover, the decrease in land surface coverage and the increase in disturbance of the surface soil has accelerated soil wind erosion. The feedback of wind erosion to grassland ecosystems is the main cause of land degradation in this area (Yan et al., 2010).

One of the main effects of wind erosion is soil particle coarsening, wherein nonerodible dry aggregates or individual coarse sand particles become more abundant at the soil surface (Chepil, 1953a; Wang et al., 2015). Previous studies have found that the soil dry aggregate size distribution is a main influence on wind erosion. The different dry aggregate size fractions can be divided into three groups according to their erodibility: < 0.42 mm, highly erodible fraction; 0.42–0.84 mm, semierodible fraction; and > 0.84 mm, nonerodible fraction (Chepil, 1953b). An important secondary factor influencing wind erosion is soil texture, which affects dry aggregate structure. In sandy soils, the < 0.125 mm particle fraction is most susceptible to depletion by wind erosion (Li et al., 2009; Yan et al., 2013). Although studies have described soil particle coarsening due to wind erosion, most have focused on either soil dry aggregate distribution or soil particle size distribution under certain wind erosion conditions. Few studies have conducted

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